

Studies of Atomic-Scale Dynamics in Materials Using Coherent X-rays

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X-ray photon correlation spectroscopy (XPCS) has emerged over the last decade as a new technique for studies of fluctuation dynamics at small length scales. Such dynamics is ubiquitous in countless processes in materials, such as viscoelastic flow of glasses, polymer diffusion, phase transitions, or domain switching. In principle, the use of x-ray wavelengths for photon correlation spectroscopy allows the study of atomic-scale dynamics in any material. In practice, however, XPCS studies using 3rd-generation synchrotrons have been limited by the available coherent flux. Experiments to date have been most successful using small-angle scattering to study dynamics of ~100 nm structures, which have sufficiently high scattering efficiency and relatively long time constants (e.g. milliseconds). Future accelerator-based x-ray sources such as free-electron lasers and energy recovery linacs will provide significantly increased coherent x-ray flux, which will greatly expand the applicability of XPCS to shorter length scales, faster time scales, and more weakly scattering systems. In particular, the ultrashort pulse structure of the new x-ray sources will allow observation of dynamics into the femtosecond range. I will discuss potential experiments as examples of the anticipated capabilities, focusing on studies of domain dynamics in ferroelectrics and new aspects of experiment design for studies at LCLS. Work supported by the U.S. Dept. of Energy contract DE-AC02-06CH11357.

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